Advantage of Electrical Operation in Mountain Districts

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We are very pleased at being permitted to reprint from *The Milwaukee Employees Magazine* for March, 1922, the following article. It is a practical contribution by a practical man—telling the actual accomplishments rather than the possibilities. The results recorded reflect credit on all concerned and are a more eloquent tribute of electric traction than volumes of mere talk.—Editor.

We are, as you all know, operating electrically on the main line over five mountain ranges, formerly the most difficult parts of the system, being the Cascade and Saddle Mountains in Washington, and the Bitter Root, Rocky and Belt Ranges in Montana, a total of about 660 route miles. We have two maximum gradients of 2 per cent to 2.2 per cent for about twenty miles; two grades of 1.6 per cent to 1.7 per cent and several of 1 per cent.

In freight service on grades of less than ½ per cent we can handle as much tonnage as the operating conditions will permit with one electric locomotive at speeds which may vary up to 30 m.p.h. On 1 per cent grade ascending one electric locomotive will handle 3,500 tons; on 2 per cent grade, 1,250 tons; on 2.2 per cent grade, 1,100 tons; all at a speed of about 15 miles per hour. We ordinarily use a helper locomotive in freight service on mountain grades so that our average freight trains will run about as follows:

Per Cent Grade	Tons
1	3,500
1.6	3,200
1.7	2,800
2.0	2,500
2.2	2,200

These ratings are based on the continuous capacity of the locomotives which occurs at 15 miles per hour at full trolley pressure of 3,000 volts.

In making comparison with the steam locomotives that were used prior to the electrification, the tonnage rating and what was actually hauled over the Rocky Mountains is as follows and applies to freight trains only:

	Tons
2 Mallets, Butte Yard to Donald	2,250
2 L2 Engines, Butte Yard to Donald	1,600
2 Electric, Butte Yard to Donald	3,200
2 Mallets, Piedmont to Donald	1,800
2 L2 Engines, Piedmont to Donald	1,400
2 Electric, Piedmont to Donald	2,500

From this you will see that the tonnage hauled over this mountain is greatly in favor of the electric motors. I might add that the mountain grade from Butte Yard to Donald is 1.6 per cent and from Piedmont to Donald on the east slope is 2 per cent.

On the 2 per cent grade over the Saddle Mountains in Washington two electric motors are hauling 2,200 tons at a speed of fifteen miles an hour, whereas two Mallet engines haul 1,600 tons at a speed of about eight or ten miles per hour.

In passenger service we are not using any helper power. These locomotives are built strong enough to handle 960 tons of passenger equipment over any portion of our track. They make good speed in ascending grades and their speed on level track is only limited by operating conditions.

In switching service we have electric locomotives at Butte, Deer Lodge and Othello. In special service we have used electric locomotives to push snow plows, on work trains and for wrecking outfits and obtained efficient results.

One thing which seems of considerable importance to the steam man in first operating an electric locomotive, and which is soon likely to be forgotten with other commonplace things, is that no stops are necessary for fuel or water. When you consider the delays, train troubles and extra work of watering engines, encountered in mountain traffic, you can see that the complete elimination of such is no small item in bettering train operation. When you consider that a large part of our mountain district is through comparatively dry territory the elimination of pumping plants to supply this water represents economy. We use water certainly, to generate power in electric operation, but we do not have to pump it nor clean out the scale it may form in boiler tubes, nor transport fuel for long distances in order to heat it for use. We merely let it drop through turbine machines, extract the power and let it go on for further usage by others in its original form. Not only does this save work in getting fuel out of the ground, but it conserves the fuel itself for use in other lines and other parts of the system where such use cannot be avoided.

Another feature which applies to all kinds of service and of which we have good report is that although the electric locomotives weigh more on drivers than any steam power, they are easier on curved track, at least, than the steam engines. On tangent track the difference is not so apparent but it may be stated that there has been no radical changes made in track construction since we electrified nor has there been any apparent reason for making changes. Considering that mountain trackage has a high percentage of curvature, this advantage of electrical operation is appreciable.

But in order to deal specifically in bringing out advantages of electric motive power in the mountains, it will be better to go more into detail and to separate the subjects into more parts. I can perhaps do this best by considering different kinds of service separately and by giving examples of actual operation.

First in importance there is the freight service in which we have reduced the number of engines required and the work of keeping them in service. We have practically reduced our running time between points by 40 per cent and have increased our tonnage in the worst districts by about the same amount. In spite of increased tonnage the drawbar reports show a decreased number of accidents of this nature after the men have become accustomed to electric operation. The fuel consumption or kilowatt-hours at the locomotive shows marked economy and there is no doubt but that with a sufficient number of trains operating, marked economy for the whole system is possible over steam operation.

Freight trains can be handled over mountain grades without stopping and due to the regenerative feature may be handled without applying an air brake on the whole train, unless for some reason it is necessary to come to a dead stop. The regenerative braking not only saves the use of brake rigging but also returns energy to the trolley which may be utilized in helping move other trains. Whatever may be the return on this regenerated energy the saving made in ease of train handling with less number of break-in-twos with consequent damage and delays, is an important advantage.

In connection with the regenerative braking feature, the various tests on brake shoes in making a run from Avery to Harlowton about one-fourth of the brake shoe was worn away in controlling the speed of the trains on mountain grade, while in the westward movement between these two points it showed approximately one-fifth of the brake shoe worn away. A conservative figure on the value of the metal dissipated through brake shoe wear during a thirty-day month period would be $6,000; this is not including the saving in the way of cracked wheels through overheating. Both of these items of expense have been practically eliminated through electric operation.

We expect at some future date to combine regenerative braking which sends the current back into the wire and which we have at present, with rheostatic braking which consumes the braking energy in the starting resistors, so that we can use electric braking at speeds down to practically a standstill. This will be a matter for experimentation but the possibilities of electrical operation are quite easily handled and are unlimited in variations which may be put to practical usage for improved operation.

Starting freight trains on ascending mountain grades is comparatively easy and not at all likely to result in drawbar damage. The helpers are placed in the middle of the train and the head locomotive can when starting let the slack back as far as the helper. The helper man then can advance his controller to give maximum tractive effort and is ready to follow with the slack when the head locomotive starts. With electric operation we have almost entirely quit "getting" drawbars in the mountains, the most of them which "cut out" now do so when making stops on early grades.

We do not need engine watchmen with electric motive power and at any point where one of these machines is tied up it is only necessary for the enginemen to drop the pantographs and shut the doors and windows. This is particularly advantageous at helper tie-up points. At Butte and Piedmont when we first electrified we had as high as six to ten steam engines, mainly required for helper service. These were replaced with two electric locomotives, which have successfully done the freight helper work since. The passenger trains not requiring helpers have to some extent made this possible of course, but this itself is also another advantage of electrical operation.

Regenerative braking makes it a decided advantage to use a helper descending a grade as well as in going up on the other side. We have only one heavy grade on the Cascade Mountains where this is not applicable.

Otherwise our helpers ordinarily go clear over the summits where used. It is common for a helper to go in a train upgrade to Boylston and down to Beverly then back to Kittitas light with zero net consumption of kilowatt-hours, or regeneration in this case, making it possible to operate helpers in eastward traffic from this point at no fuel expense whatever.

The increased safety in having two locomotives in trains of this sort on heavy grades can be appreciated.

In passenger service the delays and rough handling necessary to the operation with helpers is entirely eliminated. The same locomotive which may haul the train at 50 miles per hour can also handle it with ease and certainty on a 2.2 grade.

Here again the regenerative braking feature is important. One who has tried to sleep in a passenger train through mountain districts and has been kept awake by application of brakes at frequent intervals can readily appreciate the comfort of an electrically operated mountain trip in which it is impossible to tell from the way the train is handled as to whether a grade is being ascended or descended.

The smooth ease of handling of passenger trains is a point of merit and occasions many favorable comments from passengers about our service.

The entire absence of cinders and a certain amount of grime from coal burning locomotives is appreciated by the passengers. Complaints of delays caused by poor fuel, engine not steaming and sundry things have become things of the past. We do have our troubles with electrical failures, it is true, but these are nearly all in a class not to be called serious and fortunately are of uncommon occurrence. The small detentions here and there of large variety and frequent appearance in the past are not now evident.

In electric switching service we find that the energy or fuel expense at the locomotive has been more than cut in two over steam operation. The locomotives are quick in acceleration, easy to handle and because the engineer has little to look out for other than the operation of starting and stopping, he can lend his whole attention to the business at hand and thus get as much work done as the yardman can attend to.

The maintenance of these machines is very slight and because of taking but little energy the extra demand for power that they require is not very noticeable at the substations which furnish it.

As to special service, wherever the trolley wire goes the electric locomotive has given particularly good results. In rerailing cars or engines or pushing snow plows the uniform rate of speed for a given load and the ease with which the locomotives can be controlled make their use decidedly advantageous.

The rated tractive effort of an electric locomotive is usually given as that within the continuous or 24-hour capacity of the traction motors. This is 72,000 lb. for our freight locomotives but does not mean very much as compared to the maximum tractive effort which the locomotive can exert. This is only limited on these machines by the slipping point of the wheels. With sand used on the rail they have been known to exert a tractive force of 160,000 lb., and this could be maintained for a period of time until the tractive motors are in danger of overheating due to the large flow of current through them. Such strong tractive effort makes these machines efficient in handling certain work under adverse conditions as mentioned above.

Because the tractive effort is nearly proportional to the current flowing through the motors regardless of the speed, it is very easy to judge train weights, proper ratings and other things may be ordinarily left to a dynamometer car. In fact, every electric locomotive is equipped with its own instruments so that it is a very good dynamometer itself, and in cases where the engineer runs into conditions of overloading, he can readily judge the amount and reduce as necessary. There is no argument as to whether one man can get more out of an engine of this kind than another—they are all placed on an even basis. Moreover, the normal running times are so well made uniform that the dispatchers do not have to figure much on the personal element of the enginemen in supervising train operations.

In conclusion, I may state that the results obtained from this kind of motive power in its operating features have been found desirable. There are possibly other benefits to be derived from electrification, but I have endeavored to stay within the limitations applying to the locomotives alone. There are disadvantages too, of course, and many ways of improvements and developmental changes as is true of all electrical equipment. However, the field for experiment and such changes is large, and with the successful electric motive power we now have, we have made the start, and further improved features can be inaugurated if necessary.